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THE MEASUREMENT OF VELOCITY WITH ATOMIC CLOCKS[1]

By Dr. HERBERT E. IVES

BELL TELEPHONE LABORATORIES

ABOUT twenty-five years ago the Physical Society held a discussion of the theory of relativity, at which widely divergent views were expressed. I recollect that Professor E. W. Morley, speaking of the Michelson-Morley experiment, declared with great emphasis that this was a *physical* experiment and must have a *physical* explanation. On the same occasion a distinguished chemist, still living, declared, as his only contribution to the discussion, that the meeting would be known in history as the last time a scientific gathering treated the ether as a subject for serious discussion.

In spite of this discouragement I shall venture to discuss my subject as Professor Morley would, in terms of an ether or fixed framework. I do this partly because I know of no way to discuss the behavior of variable measuring instruments, such as atomic clocks, except by comparison with real or postulated invariant instruments. Partly also I do this because of the belief, for which I shall attempt some justification, that the ether has not yet been "abolished." I hope that even if I do not convert you to this point of view, I can enlist your sympathy for my preference for it.

It is my purpose, in the next few minutes, to discuss what happens to the measurement of *velocity* when the clocks we use for the determination of time are atomic clocks, which vary in their rate, when moving, according to a relation for which experimental evidence has recently been obtained from a study of the Doppler effect in hydrogen canal rays.[2]

As a preliminary to this discussion we must look at the concept of velocity and velocity measurement, as it

[1] Address of the retiring vice-president and chairman of the Section on Physics, American Association for the Advancement of Science, Columbus, December 29, 1939.

[2] *Jour. Optical Soc. America*, p. 215, July, 1938.

existed before the idea of clocks variable with motion was entertained. When Newton enunciated his laws of motion he made use of a concept of velocity which was based on absolute lengths and times. These were supposed to be determinable by measuring rods and clocks which were unaffected by the processes involved in their use. It is of course a commonplace of the science of measurement that all material instruments are subject to variation with temperature, humidity, aging and other conditions. It was, however, the faith of the Newtonians that by sufficient attention to the choice of materials and the control of conditions, measuring rods and clocks could be so constructed and used that the assumption of their invariance could be practically justified. The path of progress, through the development of accurate chronometers, and rods of carefully chosen alloys, would be to approximate more and more closely to instruments whose readings would confirm ever more accurately the Newtonian laws based on his concept of velocity.

A characteristic of Newtonian velocities is relativity, or Newtonian relativity, as it is sometimes called, by which was meant that velocities could be measured with the instruments and observers uniformly moving in any conceivable combination. To visualize this characteristic we may picture two freight trains passing each other. Using the freight car as our unit of length, it is indifferent whether we determine the relative velocities of the trains by counting the number of freight cars passing a clock fixed on one train; or by the time it takes a mark on a passing freight car to pass two clocks on the other train, these clocks having been set together and moved to opposite ends of a car on it. No one called in question the time measurement in the first case because the clock was moving, or in the second because one of the clocks had been moved to the other end of the car. Nor were the distances challenged because the measuring units, the freight cars, were in motion.

What now happens to such measurements if our clocks can not be made invariant with motion? This question might be investigated by the assumption of some arbitrary relation between clock performance and velocity. Or a relation might be deduced from the postulation of certain general relations (such as Newtonian relativity) which it is desired to preserve in spite of variation of clock performance. I do neither here, but start from the relation recently shown to hold experimentally for the frequency of the radiation from a hydrogen ion in motion in a canal ray tube. That is, considering such an ion as a clock emitting pulses of radiation, the frequency of the resultant radiation varies according to the relation

$$\nu = \nu_0 \sqrt{1 - \frac{v^2}{c^2}}$$

where v is the velocity of the particle, and c the velocity of light.

In thus basing my discussion on the results of an experiment rather than on certain bald assumptions, I must remind you that there is still an assumption involved. It is that the frequency change observed in the canal rays is a direct consequence of their velocity alone, and not, as some spectroscopists have suggested, a secondary effect associated with collisions or other interaction between the moving particles. If the latter should ultimately prove to be the case, certain of the perplexities which we shall shortly meet would disappear, and this particular discussion would become largely academic—to be superseded by others with their own quota of perplexities.

In addition to this variation of clock rate, I shall use the Fitzgerald contraction to represent the variation of length of the measuring rod used to determine the distance factor in velocity. This I may point out is in a somewhat different category from the frequency change. Strictly speaking, it is an inference from an experiment which is based on an assumption. The experiment is the Michelson-Morley experiment. The assumption is that the light signals used in the experiment are located in a medium through which the earth and the apparatus move. Put in another way, the assumption is that, in spite of their terrestrial origin, the light waves become part and parcel of the system of light waves from the fixed stars, with respect to which we learn, by the phenomena of aberration and the Doppler effect, that the earth moves. Or, put still differently, the assumption is that the medium conveying the light signals does not partake of or is not entrained by the movement of the earth. I do not wish to appear to question this assumption. I merely want to make clear an important difference in the evidence we have for the contraction of frequency, observed as a positive effect, and for the contraction of length, inferred from a nul effect. Until we can observe the Fitzgerald contraction by the rapid motion of objects in the laboratory this difference stands. I shall then assume the Fitzgerald contraction, merely noting that most of what I have to say is substantially unaffected if I were to confine myself to the variable clock rate, which is covered by my title.

Before experimenting with these instruments in the measurement of velocity let us take a moment to examine the physical model which we may imagine for rods and clocks which behave this way in motion. Lorentz and Poincaré have pointed out that a charged electrified sphere, held in shape by surface forces, would in motion preserve its equilibrium by taking the ellipsoidal shape represented by the Fitzgerald contraction. Similarly, a spherical reflecting shell at whose center is a source emitting pulses of radiation

set off by the reflection of previous pulses, that is, a "singing" system, would, if subject in motion to the Fitzgerald contraction, space the pulses farther apart, with a resultant frequency reduced in the ratio $\sqrt{1-\frac{v^2}{c^2}}:1$. This is the behavior of our atomic clock, which we note is different from the kind of clock which Newton would probably have picked to measure his "uniformity flowing" time. For that something of the nature of an hour-glass or clepsydra would be more inherently fitted, and for such a clock we have no evidence that a change of rate would occur on motion. Finally the electromagnetic mass of a charged sphere would be changed in motion, as shown by Lorentz, in the ratio $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}:1$ by this same change in shape, corresponding to the results of the Kaufmann and Bucherer experiments. We can thus claim to have a concrete idea of a physical model which accounts for the properties of the instruments we are to investigate.

Let us proceed now to make velocity measurements with our rods and clocks. Let the measurement be that already discussed in connection with Newtonian measurements, namely, the relative velocity of two trains of "freight cars," the cars all having been matched in length by superposition and forming our units of length. We shall first measure the relative velocity by noting the number of "cars" on one train which pass a clock at a fixed point on the other. This corresponds to the familiar method of estimating train speed by counting passing telegraph poles, or to the method of reading the log on a ship. For this measurement we have the formula

$$V_A = \frac{v \pm w}{\sqrt{1-\frac{v^2}{c^2}}\sqrt{1-\frac{w^2}{c^2}}}$$

where V_A is the relative velocity as read, v and w are the Newtonian velocities, measured by invariant rods and clocks. The factor $\sqrt{1-\frac{v^2}{c^2}}$ shows the increase in reading due to the passing freight cars being contracted in length, the factor $\sqrt{1-\frac{w^2}{c^2}}$ the increase due to the clock running slow because of its velocity. Using this convention for measuring velocity, which we shall call convention A, we note that if the velocity of either body approximates the velocity of light, the apparent relative velocity approaches *infinity*.

This does not, however, mean that the velocity of light itself, so measured, would be infinite. If we consider light as a train of waves we regard these as of invariant length with respect to the Newtonian framework, or ether, so that if we could watch the passage of successive wave-crests, there would be no factor in the measurement for the contraction of length, as in the case of a material body. Our formula for the velocity of light is then

$$V_A = \frac{c \pm w}{\sqrt{1-\frac{w^2}{c^2}}}$$

Now we can not actually watch the crests of light waves pass a clock, but it is of interest to observe that this formula is the formula for the Doppler effect. Under certain conditions we can actually measure the change on the velocity of light by the Doppler effect, in conformity with this convention. Thus if we measure the Doppler shift of a line in the spectrum of a star in the east in the early evening, and again in the west in the early morning, the change in observed wave-length gives the change in the velocity of light relative to the earth's surface, due to the earth's axial velocity. This is the only interpretation, unless we are so hopelessly geocentric that we believe the whole stellar universe oscillates with a 24-hour period in order to maintain the velocity of light constant with respect to the earth!

This convention of velocity measurement requires that the clock be on one body, the measuring unit on the other. It becomes inoperative, if one of the bodies is a point without extension, or, in the case of light, if the velocity of a single light pulse is to be measured. For these conditions another convention, entirely equivalent in the Newtonian system, is available. It consists in noting the time of passage of a point on one "train" past the two ends of a freight car on the other. This corresponds to timing a race by watches at the two ends of the course. Here at once we meet with a fundamental difficulty. The clock at the far end of the freight car, or the race course, must be set to agree, not only in rate, which we can assume can be accomplished with sufficient precision, but for its zero, with that at the initial point. Let us set the two clocks together at the initial point. We must then transport one clock to the distant point. We must do this at *some* velocity, and while so doing we change its rate. In consequence we accumulate a difference of setting, which remains after the clock has reached the distant point. Our readings of time interval are therefore functions of the speed with which we have moved the clock.

The formula for relative velocity applying to this case, which will be called the B convention, is

$$V_B = \frac{v \pm w}{\left(1 \pm \frac{vw}{c^2}\right) - \left(\frac{v \pm w}{c}\right)\left[\frac{\sqrt{1+\frac{w_c{}^2}{c^2}}-1}{\frac{w_c}{c}}\right]}$$

where w_c is the observed velocity of transport of the clock as measured by the A convention above.

For the case where the velocity v is the velocity of light we have

$$V_B = \frac{c \pm w}{\left(1 \pm \frac{w}{c}\right) - \left(1 \pm \frac{w}{c}\right)\left[\frac{\sqrt{1+\frac{w_c^2}{c^2}}-1}{\frac{w_c}{c}}\right]},$$

which becomes

$$= \frac{c}{\left[1 \pm \frac{w_c^2}{c^2}\right]}$$

for small values of $\frac{w_c}{c}$. That is, the measured velocity of a particle moving with the velocity of light or of a light pulse is always *greater than c.*

Inspecting these formulae, we see that, as the observed velocity of transport of the clock becomes infinitely small, the limiting value for observed relative velocity is

$$V_{B'} = \frac{v \pm w}{1 \pm \frac{vw}{c^2}}$$

which for $v = c$ gives

$$V_{B'} = c$$

We can tabulate these results as given in Table 1.

rods and clocks, is the only firm foundation, of sufficiently wide base, that we can use as a starting point for speculation.

The second question refers specifically to the B′ convention, that is, the use of clocks transported infinitely slowly. This will be recognized from the resulting formulae as that embodied in the Lorentz transformations and in Einstein's Special Theory of Relativity. The latter was actually evolved in terms of the velocity of light taken as a constant "*c.*" The fact that this postulate is equivalent to the prescription of clocks moved infinitely slowly, of lengths measured by rods laid alongside, has long been recognized, but not, I think, with the critical attitude that it deserves. What Einstein's second postulate amounts to (as is clear from his own original statement, rarely reproduced in full) is *a statement of a measuring procedure which is to be adhered to.* There is no philosophical justification offered for this procedure, which, as we have seen, is not the only one. It is justified only on the ground that the velocity of light is "*c*" "as derived from experiment." The fact is that the velocity of light has been measured practically by methods equivalent to the B′ convention. Had the clocks used been moved with other than infinitesimal velocity, experiment would have yielded different values for the velocity of light. The second postulate

TABLE 1

	Formulae for relative velocities	Particle moving with velocity of light	Velocity of light
Convention A	$V_A = \frac{v \pm w}{\sqrt{1-\frac{v^2}{c^2}}\sqrt{1-\frac{w^2}{c^2}}}$	$V_A = \infty$	$V_A = \frac{c \pm w}{\sqrt{1-\frac{w^2}{c^2}}}$
Convention B	$V_B = \frac{v \pm w}{\left(1 \pm \frac{vw}{c^2}\right) - \left(\frac{v \pm w}{c^2}\right)\left[\frac{\sqrt{1+\frac{w_c^2}{c^2}}-1}{\frac{w_c}{c}}\right]}$	$V_B = \frac{c}{\left[1-\frac{1}{2}\frac{w_c^2}{c^2}\right]}$	$V_B = \frac{c}{\left[1-\frac{1}{2}\frac{w_c^2}{c^2}\right]}$
Convention B′ $\left(\frac{w_c}{c} \simeq 0\right)$	$V_{B'} = \frac{v \pm w}{1 \pm \frac{vw}{c^2}}$	$V_{B'} = c$	$V_{B'} = c$

With this table before us several questions present themselves. It is pertinent to ask which convention of measurement is "correct." (In the Newtonian scheme this question does not arise, since they are all equivalent.) I think the only possible answer is that one is as correct or incorrect as another. The thing which is undermined is the idea, inherited from the Newtonian framework, that velocity is, from the standpoint of measurement with available instruments, a uniquely determinable quantity. We are in this matter the slave of our instruments. My own conclusion is that the Newtonian framework, with its invariant is then a prohibition on the use of any but one measuring procedure. This prohibition has no explanation except when studied, as we have studied it, with reference to the Newtonian framework. Many of the popular paradoxes and metaphysical speculations connected with the subject are largely peculiarities of this procedure. I have in mind particularly those speculations which transfer the properties of our rods and clocks to the nature of space and time, and seek to overlay the Newtonian conception of these with warped and imaginary attributes. This prescription of a special convention of velocity measure-

ment, I may remind you, applies not only to the Special Theory of Relativity, but to the General Theory, which is a speculation on the properties of the so-called "chronotopic interval," which is a function of the same convention of measurement.

I am well aware that in thus objecting to a prescribed but not unique measuring procedure as the method of studying a branch of physics I am out of step with many present writers on physical theory. The statement has been made, and repeated with approval, that the sole object of physical theory is the ability to predict the results of experiment. Formulae whose derivation is shrouded in obscurity, but work, are extremely popular. Notwithstanding this, such an attitude, while justified perhaps in engineering, or in a new and largely unsystematized branch of science, deserves, I feel, no permanent place in a system of natural philosophy.

A topic intimately related to this study of velocity measurement with atomic clocks is the question of the existence of a fundamental reference framework or medium such as I have assumed in this discussion. I have expressed the opinion above that the Newtonian framework with its implied invariant rods and clocks is the only satisfactory basis for discussion of this subject. The luminiferous ether of Maxwell and his followers has the characteristics of such a framework. In it the velocity of light has the value c when measured by invariant rods and clocks. It has been claimed, and the claim has received wide popularization, that this framework or medium is non-existent because the theory of relativity shows that it is unnecessary.

I want for a moment to examine this claim in the light of the previous discussion. What it actually amounts to is this: that in place of a physical concept, built on a wide range of experiments, which include all the wave phenomena exhibited by light, and such well-established facts as the aberration of light, we are asked to substitute a procedure of measurement which narrowly restricts our freedom of instrumental manipulation. That is, if in measuring velocities we agree to use only that method of time measurement which employs two clocks, and agree never to move our rods or clocks at more than negligible velocities, and if we are content not to worry about the reason for using this restricted measuring procedure, then we do not need, we can indeed, in a sense, "abolish" the ether. It is an eminently practical procedure, since we can not ordinarily move our rods and clocks at any but negligible velocities; but that it "abolishes" the ether or removes its need for the full consideration of the subject is, I think, an unwarranted claim. It is equivalent to telling the driver of a car that he can dismiss the engine from his mind, because if he presses the ignition button and moves clutch and throttle in a certain way the car will go; or to telling a locomotive engineer that geography is no longer necessary, because he can reach his destination if he will stick to the tracks and obey the signals. These working rules do not, I contend, "abolish" the engine or geography.

There is another argument which is often made against the luminiferous ether, namely, that it can not be physically detected, and hence, being unobservable, is equivalent to being non-existent. This argument, whether or no it is even tenable philosophically, is, I think, untenable in the light of one of the classic experiments in the field of optics, namely, the Sagnac experiment. In this experiment a beam of light is divided and sent in two directions around the periphery of a disc, which can be set in slow rotation. When so rotated an interference pattern between the two beams is shifted, by exactly the amount predicted on the assumption that the light is located in a fixed medium, with respect to which the apparatus revolves. (On a much larger scale, using the earth as the disc, the Michelson-Gale experiment gives the same result.) The Sagnac experiment has been repeated recently by Dufour and Prunier with various modifications, such as a stationery light source outside the apparatus, always with the same result. It shows that the velocity of light with respect to the disc is $c \pm r\omega$.

Now as I have shown elsewhere,[3] if on this apparatus we measure our time by atomic clocks carried (infinitely slowly) around the disc, thus employing the Einstein measuring convention, we would decide that the velocity of light is c, instead of $c \pm r\omega$. But we would find that these clocks were out of setting with one left at the origin, showing quite conclusively that the measured value c was a consequence of the movement of the transported clocks. Now if we use a very large disc, a portion of whose periphery is indistinguishable from a chosen straight path, we find that for both straight path and disc path the velocity of light measures c by the Einstein convention, but by continuing around the disc we have clearly demonstrated that this value is a function of the method of using the clocks. We must of course admit that the light has the same velocity whether sent along the short straight path or the short portion of the curved path indistinguishable from it. The only reasonable conclusion is that it has the value $c \pm r\omega$ in both cases. The properties of a moved clock (and the Fitzgerald contraction) give a complete explanation of why we obtain the value c in one case; $c \pm r\omega$ in the other.

The significance of the Sagnac experiment has been questioned by adherents of that article of faith that the velocity of light is always "c," but in my opinion

[3] *Jour. Optical Soc. America*, p. 296, August, 1938.

without success. It has been contended that it is the same kind of experiment as the Foncault pendulum, owing its result, in some manner not made clear, to the influence of "all the matter in the universe." "All the matter in the universe" thus becomes a new fixed framework, which is going far afield, for questionable gain, from the luminiferous ether which so directly and accurately explains the experiment. At any rate it can not be gainsaid, I think, that all the experiments in this field, from the aberration of light, through the Michelson-Morley and Kennedy-Thorndyke experiments, the recently demonstrated variation of atomic clock rate and the Sagnac and Michelson-Gale experiments, are consistently and satisfactorily described in terms of a luminiferous ether.

In conclusion, let me summarize the point of view I have adopted in these remarks, and the chief points I have tried to make. I have endeavored to present the subject from the standpoint of the experimental physicist, to whom the properties of his apparatus must be constantly under scrutiny, so that he may not ascribe to the phenomena he is observing what are in fact peculiarities of his instruments. I have taken the variation of atomic clock rate with velocity as indicated by experiment, and inyestigated the influence such variation will have on the measurement of one of the fundamental factors in physical theory, namely, velocity. It develops that a variety of "velocities" can be measured with such clocks, no one of which has any *a priori* claim to be chosen as "correct." They are all deviations from the simple Newtonian concept of velocity, which is in terms of rods and clocks which are unaffected by motion. I urge the merit of the Newtonian framework as the only unambiguous basis for the idea of velocity. I have further pointed out that one of the conventions for measuring velocity when using variant clocks is equivalent to the Lorentz transformations and the Second Postulate of the Restricted Theory of Relativity. Conversely, this postulate is nothing more than a specification of a method of measurement to be used to the exclusion of others. Conclusions drawn from it are consequently of limited applicability and significance. They constitute no ground for revolutionizing the Newtonian ideas of space and time. I have considered the popular claim that the ether has been "abolished," and pointed out that the essence of this claim is that for the ether it is proposed to substitute a particular prescribed measuring procedure, which has no justification except as derived from considerations involving the ether.

Reverting to experimental findings I have reviewed the experiment of Sagnac, having in mind the claim that the ether can not be detected experimentally. I have asserted that, in the light of the experimentally found variation of clock rate with motion, this experiment does detect the ether, and that it and others in this field are all in complete agreement with the existence of a fixed framework. These views will be recognized as those of the earlier students of the subject—Fitzgerald, Larmor, Lorentz—but not of those who would shift the burden from variant measuring instruments to the nature of space and time. If you remember my opening paragraph, you see that I stand with Professor Morley.

CONSTITUTIONAL BARRIERS TO INVOLVEMENT OF THE NERVOUS SYSTEM BY CERTAIN VIRUSES[1]

By ALBERT B. SABIN, M.D.

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IT has been realized for some time that in nature not all who are infected with certain neurotropic viruses exhibit signs of central nervous system disease; indeed, the number of those who develop paralysis or encephalitis may constitute a very small proportion of the total number of the animal or human population which is infected. The hypothesis that exposure to small doses of an unmodified, virulent, neurotropic virus can immunize without producing infection is still without experimental basis, because in the laboratory one usually finds that the dose is either large enough to initiate multiplication and infection or is too small to give rise to an immune response. Why, then, is infection apparent in some and inapparent in others? Instead of assuming that the major portion of a population is resistant because it has somehow acquired a specific immunity, we may inquire whether it might not be the other way around, *i.e.*, that immunity develops without disease because of some preexisting constitutional resistance. In the investigations which I shall now summarize an attempt

[1] Address delivered on December 28, 1939, to the Section on Medical Sciences upon receipt of the Theobald Smith Award of the American Association for the Advancement of Science. The work which forms the basis of this communication was carried out at the Rockefeller Institute for Medical Research in association with Dr. Peter K. Olitsky.

was made to define some of the ways in which such constitutional resistance may operate.[2]

Studies with the viruses of vesicular stomatitis and equine encephalomyelitis have revealed a type of resistance which depends neither upon specific immunity resulting from prior exposure to infection nor upon the presence of antibodies against the virus in the blood, but rather upon the condition of some of the tissues which the virus must pass before the nervous system can become sufficiently involved to give rise to clinically apparent and fatal disease.

In nature, the immunologically distinct New Jersey and Indiana strains of vesicular stomatitis virus are responsible for a mild disease of cattle and horses without apparent involvement of the nervous system, but, experimentally, in mice these viruses can give rise to fatal encephalitis or ascending paralysis. The starting point of these investigations was the observation that as mice grow older they acquire a resistance to inoculation by intraperitoneal, intramuscular, subcutaneous, intraocular and intranasal routes, while the nervous system as a whole, as evidenced by the effect of inoculation directly into the brain, remains equally susceptible in young and old. It seemed, therefore, that certain changes associated with or the result of the process of normal growth could either modify or completely suppress the effects of peripherally inoculated virus.

It was clear that in order to obtain some idea of the nature of this resistance it was necessary to determine in considerable detail the pathways by which the virus spread after inoculation in different parts of the body. Experimental and histological studies revealed that when virus was injected directly into the brain it spread through the open ventricular system and quickly involved the entire brain and cord in both young and old mice, while after peripheral inoculation the evidence pointed to progression in a closed system of neurons and their processes, at least in the stage preceding neuronal necrosis, the distribution of virus and lesions depending upon the central associations of the primary neurons connected with the inoculated site. Thus after nasal instillation of virus in young mice fatal encephalitis follows invasion of the entire central nervous system through the olfactory neurons and their connections, progression of the virus occurring from cell station to cell station along specific tracts, as is evident from the distribution of neuronal lesions. In resistant mice the virus also invades the central nervous system, but its spread is held up in a silent area somewhere in the anterior olfactory regions, and the animals show no signs of disease. The very fact that virus could multiply and remain localized in this limited area for a period of at least 4 days without involving the rest of the brain, suggested that it had spread in a closed system, for after direct intracerebral injection of even a minimal dose there are large amounts of it throughout the central nervous system within one day; it also suggested that some barrier must have been encountered which was capable of arresting the infection. The question then came up whether this hypothetical barrier exists in the animal before it is exposed to the virus, or whether it represents a rapid acquisition of specific tissue immunity. In other words, does the virus fail to progress because the remainder of the brain has become immune by the time it is reached, or is the remainder of the brain still susceptible, the spread of the virus being inhibited by a preexisting, localized insusceptible zone? In the experiments undertaken to answer this question, an attempt was made to circumvent such a zone, if one existed, by direct intracerebral injection of minute amounts of virus in old mice at intervals of 2, 3, 4 and 5 days after nasal instillation, when the anterior olfactory regions could be expected to contain virus. For if the brain had acquired an immunity in that short time one would expect these mice to remain well, whereas if the brain as a whole were still susceptible, these animals would die, while the uninoculated controls which received virus only by nasal instillation would survive. Actually, the mice injected intracerebrally at the stated intervals after nasal instillation died and the evidence was against a rapidly acquired immunity and in favor of some preexisting barrier. Whether this barrier is an insusceptible group of neurons or an impenetrable synapse somewhere in the chain, or something else, it is clear that the halting of virus progression must also depend on the failure of the neurons, which are affected, to disintegrate and liberate virus into the open system.

The course of events after intraocular injection was investigated because the special anatomical conditions in the eye appeared to supply a good opportunity for studying further the nature of virus spread along other pathways and the modifications which develop with age. It was possible to obtain satisfactory evidence by experimental and histological techniques that after injection into the vitreous of the eye, vesicular stomatitis virus attacks the nerve cells of the retina and pursues the decussating optic pathway into the brain. [In mice the proportion of optic nerve fibers which do not decussate is apparently very small.] It could be demonstrated that after injection into the right eye, virus first appeared in the left diencephalon, mesencephalon and occipital cortex, and it was possible to produce lesions in either the right or the left lateral geniculate body and superior colliculus, depending on whether the left or the right eye was injected. It was thus apparent that the primary pro-

[2] A. B. Sabin and P. K. Olitsky, *J. Exp. Med.*, 66: 15, 1937; *ibid.*, 66: 35, 1937; *ibid.*, 67: 201, 1938; *ibid.*, 67: 229, 1938; *Am. J. Path.*, 13: 615, 1937; *Proc. Soc. Exp. Biol. and Med.*, 38: 595, 1938; *ibid.*, 38: 597, 1938.

gression of the virus after intraocular injection was also in a closed system. Since the retina and the optic nerves are actually extracranial portions of the central nervous system it is interesting to note that minimal amounts of virus produced encephalitis in 15-day-old mice as readily by the intraocular as by the intracerebral route, while at least 90 per cent. of old mice which remain just as susceptible to intracerebral injection are completely resistant to virus introduced into the vitreous. In the resistant mice the virus failed to invade the brain and the barrier appeared to be within the eye, if not actually in the nerve cells of the retina.

After intramuscular injection a different type of barrier appeared to be responsible. In young susceptible mice the virus multiplies in the muscle cells, invades the nervous system along the spinal nerves of the region and the animals die with an ascending paralysis. In old mice, however, there is no evidence of local multiplication or involvement of the muscle cells, and in spite of the injection of as much as 10 million minimal cerebral lethal doses and the local persistence for days of much of the virus, there is invasion neither of the regional nerves nor of the central nervous system, and the animals remain well. That the barrier is not in the spinal nerves is evident from the fact that the majority of old mice develop fatal ascending myelitis when the virus is injected directly into the sciatic nerve. That the virus was not forced into the central nervous system during the course of the intraneural injection was suggested by the observation that it took at least three days for virus localized in the nerve to become demonstrable in the spinal cord. To identify the nature and precise location of the barrier at the site of intramuscular injection one must have a clearer and better-founded conception than is now available of the mechanism by which a peripheral nerve, like the sciatic, is invaded by virus deposited in the muscle. If, as is probable, the virus can progress to the central nervous system only along the axons, it might first have to penetrate certain specialized nerve endings, which perhaps may not be accessible except through the cells that they supply. If this were the case, one could understand how the mere presence of a large amount of virus without the simultaneous capacity to attack the cells might fail to involve the nerve endings. And yet there is evidence to suggest that the nerve endings themselves may perhaps constitute the barrier, as will be pointed out when the behavior of this virus in guinea-pigs is discussed. Before ending our consideration of the behavior of this virus in mice it may be interesting to note that just as different structures apparently function as barriers along different pathways, so is resistance demonstrable at different ages, depending upon the route of virus inoculation. With the intraperitoneal route it is found as early as the fifteenth day of life, with the intramuscular and intraocular routes it appears sometimes during the fourth week, while for nasal instillation it becomes apparent after the fourth week and affects between 50 and 90 per cent. of the animals in different groups of mice.

Although the central nervous system of guinea-pigs is about as susceptible to vesicular stomatitis virus as that of mice, nasal instillation of the virus produces encephalitis only occasionally in very young guinea-pigs and not at all in old ones. When the nasally instilled virus was traced in young guinea-pigs it was found that it always invaded the central nervous system along the olfactory pathways but that it never got beyond the rhinencephalon or diencephalon; in old guinea-pigs it was possible to demonstrate a transitory multiplication in the nasal mucosa but in at least 90 per cent. of them there was no invasion of the brain. Injection of the virus into the skin of the pads or into the muscles of very young and old guinea-pigs is followed by local multiplication, but the nervous system is not invaded, and the animals remain well. The fact that direct intrasciatic inoculation frequently led to a fatal ascending myelitis tends to eliminate the peripheral nerves themselves as the barriers to invasion of the central nervous system and suggest a consideration of the myoneural junctions and other specialized nerve endings, through which is effected the intimate relationship between the axis cylinders and the inoculated tissues. The striking difference between guinea-pigs and mice in relation to this virus is that the guinea-pigs, at a very early age, possess the barriers which mice acquire considerably later in life.

There are a number of other instances in nature where a virus may be highly neuroinvasive in one species and either not at all or very rarely in another. As a classical example, one may cite the virus which causes only herpes simplex in man, but when transferred to the skin, cornea or mucous membrane of the rabbit gives rise not only to local lesions like those in man, but also clinically apparent and fatal disease of the central nervous system.

It is well established that not all neurotropic viruses invade the nervous system in the same manner, and the barriers which may come into play with one virus may be entirely without influence on another. In the course of investigations on the mode of spread of the equine encephalomyelitis viruses still another type of resistance that develops with age was encountered. The change appears to be in the blood vessels which the equine encephalomyelitis viruses must traverse or grow through in most instances in order to invade the central nervous system.

With the eastern strain of equine encephalomyelitis virus young and old mice are equally susceptible to

infection by the intracerebral or intranasal routes. After intramuscular or intraperitoneal inoculation, however, 15-day-old mice are all susceptible while at one month of age 40 to 50 per cent. are already resistant, and beyond the age of three months this resistance rises to 95 per cent. After intramuscular injection in young mice this virus was found to invade the central nervous system along the local peripheral nerves in only about 5 per cent. of the animals, while in most of the others it appears to be eliminated from the blood onto the olfactory mucosa from where it invades the brain along the olfactory pathways. Studies on the nature of the resistance in older mice revealed that it is bound up with a failure of the virus to traverse the blood vessels, for the systemic phase of the disease, with virus circulating in the blood, occurs in both young and old animals. In guinea-pigs there is an indication that virus in the blood may pass or grow across the vessels directly into the brain and it is interesting that here too old animals were found to be resistant except when overwhelming doses were injected. That similar factors may play a role in human beings is suggested by the fact that in the first epidemic of this disease in man the majority of cases occurred in children, and also by the observation that adult laboratory workers may develop antibodies against the virus without having exhibited any signs of disease of the nervous system.

With the western strain of the mouse-passage virus, the first evidence that age has produced some change in the animal is found in the fact that after injection into the muscles of a hind leg, 80 to 90 per cent. of 15-day-old mice develop signs of encephalitis and the rest, signs of flaccid paralysis, while at 21 days the ratio is reversed, the majority developing flaccid paralysis, and about 20 per cent. resisting altogether. At one month of age and beyond, 90 per cent. or more are resistant to intramuscular inoculation, although injection directly into the sciatic nerve results in the paralytic disease in a large proportion of the animals. There are thus at least three phases during the maturation of the mouse, at which the neuroinvasiveness of the western virus is differently affected: first, at 15 days of age when certain vessels still permit the virus to traverse and spread in the central nervous system by some definite pathway; second, at the age of 21 days when the virus can no longer do this in the majority of mice, but now progresses along the nerves supplying the inoculated muscle; and third, between the 21st and 30th days of life when the appearance of some change in the muscles or specialized nerve endings in the great majority of mice now prevents invasion of the nervous system altogether.

Finally it should be noted that practically all the animals in whom constitutional resistance operated in one form or another to arrest and render inapparent, infection with the vesicular stomatitis or equine encephalomyelitis viruses ultimately developed specific immunity of the entire body, including humoral antibodies. This, at least as regards these neurotropic viruses, is an excellent illustration for the hypothesis that specific immunity without apparent disease is the result of preexisting resistance rather than the reverse.

In summary, it may be said, therefore, that as a result of the special mode of spread of certain viruses from the periphery into the central nervous system and also within it, the insusceptibility or inavailability of certain isolated tissues or structures, rather than resistance or immunity of the whole animal can act as a barrier to virus progression and prevent the development of apparent disease of the nervous system. While this mechanism may be only one among a number of others which operate in protecting the major portion of the animal and human population from disabling or fatal disease of the nervous system, it is especially interesting because it lends itself to the kind of experimental manipulation by which one may attempt to change susceptible individuals into resistant ones.

OBITUARY

ROY GRAHAM

DR. ROY GRAHAM, geologist at the Britannia Mines, British Columbia, was fatally crushed by a fall of rock in the mines on August 10, 1939. Thus tragically a life of unusual promise was brought to a close. Graham received his undergraduate education at the University of British Columbia, graduating in 1930 and receiving the master's degree in 1931. From 1931 to 1933 he held a fellowship in geology at the University of Chicago, where, under Dr. A. C. Noé, he became interested in the field of paleobotany, writing his doctor's dissertation (1933) on the Pennsylvania flora of Illinois as revealed in coal balls.

His excellent record at Chicago brought him the award of a National Research Fellowship in the fall of 1933 and enabled him to spend a year at Cambridge, England, studying under the distinguished English paleobotanist, Professor A. C. Seward. Returning to America in the fall of 1934, Graham soon thereafter was appointed to an assistantship at the University of British Columbia, serving in that capacity until May, 1937, and spending his summers in field work in Saskatchewan under the auspices of the Geological Survey of Canada.

His greatest talents and keenest desires lay in the field of paleobotanical research, but while awaiting

an adequate opportunity in that restricted field he turned his energies to applied geology, in which he was also much interested, serving in the summer of 1937 as geologist with the Consolidated Gold Alluvials Company of Wingdam, British Columbia, and later serving for nearly two years as geologist with the Britannia Mining and Smelting Company, Britannia, British Columbia.

Graham described nine, or about half, of the new species thus far identified from American coal balls, and there is little doubt that his species are based on substantial distinctions. It is chiefly to Graham's work that we must turn to learn of the paleontological distinctions between the flora of higher McLeansboro of Illinois and the well-known Lower Coal Measures flora of England. Other contributions have generally lacked the essential paleontological outlook which he possessed, so that generalized identifications which tended to obscure the age relations were elsewhere carried into our literature. There can be no question that Graham's work was of high caliber and, in comparison with the rest of our fragmentary knowledge, exceedingly valuable. Consequently, his loss was a serious one to this rather neglected field of science in America.

He will be greatly missed by his former teachers and associates, who were not slow to discover the earnest, lofty but friendly spirit beneath a somewhat shy exterior.

EDSON S. BASTIN

RECENT DEATHS

DR. HENRY L. SWAIN, professor of diseases of the ear, throat and nose of the Medical School of Yale University, died on January 11 at the age of seventy-five years.

DR. CHARLES E. COATES, dean emeritus of the College of Pure and Applied Science at the Louisiana State University, known for his work as sugar technologist, died on December 27 in his seventy-fourth year.

ALBERT H. BUMSTEAD, for twenty-five years chief cartographer of the National Geographical Society, died on January 9 at the age of sixty-four years.

EDMUND NEVILLE NEVILL, late director of the Government Observatory at Natal, died on January 17 at the age of ninety-three years.

Nature reports the death of Dr. Eduard Fischer, professor of botany at the University of Bern from 1897 until 1933, and of Prince Ginori Conti, the Italian industrial chemist.

SCIENTIFIC EVENTS

SCIENTIFIC RESEARCH AND TECHNICAL DEVELOPMENT IN GREAT BRITAIN

IT is announced in *Nature* that an Advisory Council on Scientific Research and Technical Development has been set up by the British Minister of Supply to advise him on scientific and technical problems. The main functions of the council will be to ensure that the work of the Directorate of Scientific Research is carried out with due regard to recent advances in scientific knowledge, to introduce new fields of research and development and to make recommendations regarding the most effective use of scientific personnel. The chairman of the council is Lord Cadman, emeritus professor of mining and petroleum technology in the University of Birmingham, chairman of the Anglo-Iranian Oil Company, Ltd., and of the Iraq Petroleum Company, Ltd. The Admiralty, Air Ministry and Ministry of Home Security are also represented on the council, of which the joint secretaries are E. T. Paris and F. Roffey, of the Ministry of Supply, Adelphi, W.C.2.

The council is constituted as follows:

Professor E. N. da C. Andrade, professor of physics, University College, London; Dr. E. V. Appleton, secretary, Department of Scientific and Industrial Research; Sir Joseph Barcroft, formerly professor of physiology, University of Cambridge; Professor W. L. Bragg, Cavendish professor of physics, University of Cambridge; Major-General E. M. C. Clarke, director of artillery (military adviser), Ministry of Supply; Professor J. D. Cockcroft, professor of natural philosophy, University of Cambridge; Major-General A. E. Davidson, controller of mechanization development (military adviser), Ministry of Supply; Dr. H. J. Gough, director of scientific research, Ministry of Supply; Dr. H. L. Guy, chief engineer, Mechanical Engineering Department, Metropolitan-Vickers Electrical Co., Ltd.; Sir Harold Hartley, vice-president and director of research, L.M.S. Railway, and chairman of the Fuel Research Board; Professor I. M. Heilbron, professor of organic chemistry, University of London; Professor A. V. Hill, secretary, Royal Society, and Foulerton research professor (physiology); Professor R. S. Hutton, professor of metallurgy, University of Cambridge; Sir Robert Robertson, director of the Salters' Institute of Industrial Chemistry, formerly government chemist; Sir Robert Robinson, professor of chemistry, University of Oxford; J. Rogers, deputy director-general of explosives, Ministry of Supply; Sir Frank Smith, director of instrument production, Ministry of Supply, director of research, Anglo-Iranian Oil Co.; Professor R. V. Southwell, professor of engineering, University of Oxford; Professor G. I. Taylor, Yarrow research professor of the Royal Society (engineering); Sir Maurice Taylor, senior military adviser, Ministry of Supply; Sir Henry Tizard, rector of Imperial College of Science, chairman, Aeronautical Research Committee.

THE WORK OF THE COMMONWEALTH FUND

THE twenty-first annual report of the Commonwealth Fund, founded in October, 1918, by Mrs. Stephen V. Harkness "to do something for the welfare of mankind," has been issued.

Attention is called to the circumstance that "every one of the major objectives to which the fund has devoted its resources during these twenty-one years—the betterment of health and of medical service, the enhancement of mental hygiene, the maintenance of international contacts through education—is threatened by war, and the hope of achieving something real and lasting for the welfare of mankind grows dimmer, at least for the time being, with each step toward world-wide violence."

In describing accomplishments of the fund since its foundation, the report says:

> The present objectives of the fund have been worked out gradually. Its first appropriation, made in 1918, was for war service and relief. In that and the two following years large sums were given to the American Relief Administration; nearly two and a half million dollars were appropriated between 1918 and 1925 in support of American efforts to patch up a shattered civilization by meeting the simplest of human necessities. Before these emergency gifts had wholly tapered off, the fund had begun to help in a planned program for the upbuilding of child health in Austria, to which nearly three quarters of a million dollars were devoted before the fund felt able to withdraw in 1929.
>
> During these early years gifts for medical research and hospitals were made occasionally as part of a philanthropic program ranging broadly over education, medicine and social work. In 1921 and 1922 the fund turned a considerable part of its income into two major channels, one leading to the promotion of physical health, the other of mental health, among children. Interest in physical health assumed larger and larger proportions; in 1926 a hospital-building program was developed; in later years grants for medical research and formal medical education multiplied. Total expenditures in this range of activities now exceed thirteen and a half million dollars. For work in mental hygiene the fund has appropriated in all nearly seven million dollars. The fellowships which have brought British graduate students to American universities, first offered in 1925, have absorbed more than three and a quarter million dollars. These are the main streams of the fund's giving.

Appropriations for the year 1938–1939 amounted to $1,919,908. This sum is smaller than that for the preceding year. The report states that the income was also reduced for this period, but that comparisons are misleading because of the considerable variation from year to year in the commitments against future income which are included in current appropriations. These commitments also lessen the significance of the comparisons which may be drawn between allocations to one field of work or another in successive years. About two thirds of the total appropriations made in 1938–1939 were for the promotion of health through medical education, medical research, public health and the rural hospital program.

In reference to the British fellowships it is stated that British authorities have indicated their desire to interfere as little as possible with the plan, though the fellowships for the coming year have been curtailed through force of circumstances.

AWARDS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

THE American Society of Civil Engineers opened its eighty-seventh annual meeting in New York City on January 17.

Colonel John P. Hogan, until recently chief engineer of the World's Fair, was introduced as the president-elect of the society. The following newly elected vice-presidents were also introduced: George L. Lucas, New York City, and Joseph Jacobs, Seattle, Wash.

Honorary membership in the society was conferred on Professor Thomas Ulvan Taylor, dean emeritus of the College of Engineering of the University of Texas. The presentation was made by Henry S. Jacoby, emeritus professor of bridge engineering, of Cornell University. Dean Taylor was eighty-two years old on January 2. Professor Jacoby will be eighty-three years old on April 8. When Dean Taylor was graduated from Cornell in 1895 it was Professor Jacoby who conferred the degree upon him.

Honorary membership was also conferred on Colonel H. S. Crocker, past president of the American Society of Civil Engineers of Denver, and on J. M. R. Fairbairn, of Montreal. The honors were conferred by D. H. Sawyer, outgoing president of the society, and chief of the Real Estate Section, Public Buildings Administration, Washington.

The Norman Medal, awarded for the best paper on an engineering subject, was presented to Charles H. Lee, of San Francisco. The J. James R. Croes Medal, also given for an outstanding paper, was presented to Professor C. A. Mockmore, head of the department of civil engineering at the Oregon State College, Corvallis.

The James Laurie Prize, given for a paper in the field of construction, was presented to Stanley M. Dore, of the Water Supply Commission of Massachusetts, Boston. The Arthur M. Willington Prize, given for a paper in the field of transportation, was presented to Rufus W. Putnam, of Chicago.

The Collingwood Prize for juniors was presented to Benjamin K. Hough, Jr., of Ithaca, N. Y. The Rudolph Hering Medal, given for a paper in the field of sanitation, was presented to Albert J. Schafmayer,

Chicago. The Construction Engineering Prize was presented to Howard L. King, of Lackawack, N. Y.

THE WILKES EXPLORING EXPEDITION

THE centenary celebration by the American Philosophical Society, Philadelphia, of the Wilkes Exploring Expedition of the United States Navy, 1838–1840, and a symposium on American Polar Exploration will be held on February 23 and 24 in the hall of the society, Independence Square.

The program follows:

Friday Morning, February 23

Roland S. Morris, president, in the chair

THE WILKES EXPEDITION

Edwin G. Conklin, vice-president and executive officer, American Philosophical Society, and James A. G. Rehn, corresponding secretary, Academy of Natural Sciences of Philadelphia. "Connection of the American Philosophical Society and the Academy of Natural Sciences of Philadelphia with Our First National Exploring Expedition."

Captain G. S. Bryan, Hydrographic Office, U. S. Navy. "The Purpose, Equipment and Personnel of the Wilkes Expedition."

William H. Hobbs, professor emeritus of geology, University of Michigan. "The Discovery of Wilkes Land, Antarctica."

F. W. Reichelderfer, chief, U. S. Weather Bureau. "The Contributions of Wilkes to Terrestrial Magnetism, Gravity and Meteorology."

Harley H. Bartlett, chairman, department of botany and director, Botanical Garden, University of Michigan. "The Expedition Reports and the Work of the Specialists in Science."

Mary E. Cooley, instructor in geology and geography, Mount Holyoke College. "The Exploring Expedition in the Pacific."

Luncheon for members and invited guests, 1 o'clock.

Friday Afternoon

Vilhjalmur Stefansson, Arctic explorer; past president of the Explorers Club, in the chair.

AMERICA IN THE ANTARCTIC

Colonel Lawrence Martin, chief, Division of Maps, Library of Congress. "The First Discovery of Antarctic Land by Captain Nathaniel Brown Palmer of Stonington, Connecticut."

John E. Hoffmeister, professor of geology, University of Rochester. "James Dwight Dana's Studies of Volcanoes and of Coral Islands."

Henry W. Fowler, curator of fishes, Academy of Natural Sciences of Philadelphia. "The Fishes Obtained by the Wilkes Expedition."

Captain Harold E. Saunders, U. S. Navy. "The Flight of Admiral Byrd to the South Pole and the Exploration of Marie Byrd Land."

W. L. G. Joerg, chief, Division of Maps and Charts, The National Archives. "Demonstration of the Peninsular Nature of Palmer Land, Antarctica, through Ellsworth's Flight of 1935."

Earle B. Perkins, zoologist of the Second Byrd Antarctic Expedition; assistant professor of zoology, Rutgers University. "Animal Life of the Antarctic." (Moving pictures.)

Friday Evening Lecture, 8:15 o'clock

Laurence M. Gould, senior scientist and second-in-command, First Byrd Antarctic Expedition; professor of geology, Carleton College. "Glaciers of the Antarctic." The lecture will be followed by a reception.

Saturday Morning, February 24

Dr. Isaiah Bowman, president of the Johns Hopkins University, in the chair

AMERICA IN THE ARCTIC

W. Elmer Ekblaw, scientist of MacMillan's four-year Arctic Expedition; professor of geography, Clark University. "The Arctic Voyages and the Discoveries of DeHaven, Kane and Hall."

Commander Edward Ellsberg, U. S. Naval Reserve, author of the *Saga of the Jeannette*. "The Drift of the *Jeannette* in the Arctic Sea."

Brigadier General David L. Brainard, U. S. Army (*ret.*). "The Ill-fated Greely Expedition of 1882–83 and the Farthest North of Lockwood and Brainard."

Vilhjalmur Stefansson, Arctic explorer; past president of the Explorers Club. "New Lands and Seas Discovered by Stefansson's Arctic Expeditions."

Hugh J. Lee, Peary's companion on the crossing of Greenland, 1895. "Peary's Transactions of North Greenland, 1892–95."

Captain Robert A. Bartlett, Lieutenant Commander, U. S. Naval Reserve, commander of the Arctic ship *Roosevelt* and Peary's principal assistant. "Peary's Extended Exploration of Arctic Lands Culminating in the Attainment of the North Pole."

Luncheon for members and invited guests, 1 o'clock.

SCIENTIFIC NOTES AND NEWS

THE Gold Medal of the Royal Astronomical Society, London, has been awarded to Dr. Edwin P. Hubble, director of the Mount Wilson Observatory, "for outstanding work on distances, velocities, distribution and nature of extra-galactic nebulae."

THE Symons Gold Medal of the Royal Meteorological Society, London, has been awarded to Professor Dr. J. Bjerknes, of the Geophysical Institute at Bergen.

DR. ALBRECHT PENCK, professor of geography at Berlin, has been elected an honorary member of the Norwegian Geographical Society.

THE National University of Ireland has conferred the honorary degree of doctor of science on Dr. F. G.

Donnan, professor of chemistry emeritus of the University of London.

THE rank of Commander of the Order of Leopold has been conferred by the King of the Belgians on Dr. Corneille Heymans, professor of pharmaco-dynamics at the University of Ghent. Last November Dr. Heymans was awarded the Nobel Prize in physiology and medicine for 1938 in recognition of his work on the sinus aorta mechanism in breathing.

DR. E. W. GUDGER, associate ichthyologist and bibliographer of the American Museum of Natural History, has been elected a corresponding member of the Zoological Society of London.

PROFESSOR FRANCIS CARTER WOOD, director of the Institute of Cancer Research of Columbia University and director of the laboratories and of the Roentgen Department for Therapy of St. Luke's Hospital, delivered the Carmen Lecture before the December meeting in Atlanta of the Radiological Society of North America. At the completion of his lecture he was presented with the Gold Medal of the society "in recognition of achievement in the science of radiology."

THE Oersted Medal of the American Association of Physics Teachers, awarded annually for "notable contributions to the teaching of physics," was presented at the Columbus meeting to Dr. Benjamin H. Brown, emeritus professor of physics at Whitman College, Walla Walla, Wash.

HOWARD W. BLAKESLEE, general science editor of The Associated Press, was presented at a luncheon meeting at Cornell University on January 20 with the Wilson L. Fairbanks Award of the American College Publicity Association as "the individual who has done the most for the interpretation of higher education to the general public." The morning session was devoted to a discussion of "Science in the News," Mr. Blakeslee giving the newspapers' view-point; Professor O. F. Curtis, of the department of botany of Cornell University, the view-point of scientific men, and Dean S. C. Hollister, of the College of Engineering, the view-point of the colleges.

THE officers of the American Society of Naturalists for 1940 are: *President,* Dr. J. H. Bodine, professor of zoology and head of the department at the State University of Iowa; *Vice-president,* Dr. Karl Sax, professor of botany at Harvard University; *Treasurer,* Dr. Harold H. Plough, Rufus Tyler Lincoln professor of biology at Amherst College; *Secretary,* Dr. Ralph E. Cleland, professor of botany and head of the department at Indiana University. Honorary members elected at the Columbus meeting were Dr. J. McKeen Cattell, Dr. Edwin G. Conklin and Dr. L. R. Jones.

OFFICERS of the American Society of Zoologists were elected at the Columbus meeting as follows: *President,* Dr. W. R. Coe, professor of biology at Yale University; *Vice-president,* Dr. D. H. Wenrich, professor of zoology at the University of Pennsylvania; *Secretary,* L. V. Domm, research associate in zoology at the University of Chicago; *Member of the Executive Committee,* Dr. J. T. Patterson, professor of zoology and director of zoological research at the University of Texas.

DR. E. N. TRANSEAU, professor of botany at the Ohio State University, was elected at the Columbus meeting president of the Botanical Society of America, and Dr. Neil E. Stevens, professor of botany at the University of Illinois, was elected vice-president.

THE Royal Astronomical Society of Canada at the annual meeting held at the University of Toronto on January 16 elected Dr. J. A. Pearce, assistant director of the Dominion Astrophysical Observatory, Victoria, B. C., president for 1940. Dr. Frank S. Hogg, of the David Dunlap Observatory of the University of Toronto, and Dr. A. Vibert Douglas, of the department of physics of McGill University, were elected vice-presidents. E. J. A. Kennedy, of Toronto, was re-elected general secretary; J. H. Horning, of Toronto, treasurer, and Dr. Peter M. Millman, of Toronto, librarian. Dr. William Findlay, professor of mathematics at McMaster University, Hamilton, Ont., will deliver the address of the retiring president before the society at the annual "at-home" held in the McLennan Physics Laboratory of the University of Toronto on January 26. He will speak on the year's achievements in astronomy and allied sciences.

DR. ALFRED H. STURTEVANT, professor of genetics and director of the William G. Kerckhoff Laboratories of the California Institute of Technology, has been appointed visiting lecturer on genetics at Harvard University for the second half of the current academic year.

DR. R. A. RASMUSSEN, instructor of agricultural chemistry at the University of Missouri, has recently been appointed assistant professor of animal husbandry at the Utah State Agricultural College, where he will have charge of the teaching and research work in animal nutrition.

PROFESSOR DONALD J. KAYS has been appointed chairman of the department of animal husbandry of the Ohio State University. He will succeed on July 1 Dr. Carl W. Gay, who has asked to be relieved of administrative work after serving for twenty years as chairman. Dr. Gay will continue as a member of the department.

THE National Foundation for Infantile Paralysis

has made a grant of $7,000 to Dr. Albert B. Sabin, of the College of Medicine of the University of Cincinnati, for a study of poliomyelitis.

DR. ELMER D. MERRILL, administrator of botanical collections, Harvard University, and director of the Arnold Arboretum, has been elected president of the Board of Directors of the Fairchild Tropical Garden at Coconut Grove, Florida. The Fairchild Tropical Garden was organized in 1935 and dedicated in March, 1938.

DR. MARTHA TRACY, dean of the Woman's Medical College of Pennsylvania, has been appointed assistant director of public health of Philadelphia. Dr. Tracy will continue as dean of the college until the end of the present college year or until her successor is elected. She has been a member of the city board of health since 1936.

CHARLES E. CHAMBLISS, of the Bureau of Plant Industry, delivered on January 18 his address as retiring president of the Washington Academy of Sciences. He spoke on "The Botany and History of Zizania Aquatica L."

DR. JULIAN L. COOLIDGE, professor of mathematics and master of Lowell House, Harvard University, is giving a series of Lowell lectures in the Boston Public Library, entitled "Topics in the History of Geometry."

CHARLES GILMAN HYDE, professor of sanitary engineering at the University of California, spoke before the Society of Sigma Xi of Iowa State College on January 11. The subject of his address was "Progress in Water Purification and Sewage Treatment."

THE New York Chapter of the American Institute of Chemists held a dinner meeting at the Chemists' Club on Friday, January 19, at 8 P.M. Dr. W. S. Landis, vice-president of the American Cyanamid Company, made an address entitled "The Training of the Chemical Executive."

WATSON DAVIS, director of Science Service, lectured on January 18 before the Lancaster Branch of the American Association for the Advancement of Science. He spoke on "Science in the News." On the same day he addressed the Rotary Club, taking as his subject "New Materials in a New World."

American Journal of Physics is the new title of the bi-monthly publication known since its inception in 1933 as *The American Physics Teacher,* according to an action taken recently by the American Association of Physics Teachers concerning its official journal. Remaining under the editorship of Professor Duane Roller, of Hunter College, and under the publication management of the American Institute of Physics, the journal will continue to stress the educational, historical, socio-economic and philosophic aspects of physics, and the instruction of students who take physics as part of a liberal education as well as of those who specialize in the science.

DR. HARRY H. LAUGHLIN resigned on January 1 from his position as assistant director of the Department of Genetics of the Carnegie Institution of Washington, at Cold Spring Harbor, Long Island. At the time of his retirement Dr. Laughlin was presented with a pair of field glasses accompanied by a letter of appreciation and good wishes to him and Mrs. Laughlin from his colleagues. A correspondent writes: "Dr. Laughlin went to Cold Spring Harbor when Mrs. E. H. Harriman established the Eugenics Record Office (now the Genetics Record Office) in the summer of 1910. He continued in charge of this office for thirty years, during which time, in 1918, it was transferred by Mrs. Harriman to the Carnegie Institution and later, in 1921, became a part of the Department of Genetics, of which Dr. C. B. Davenport was director. During this period Dr. Laughlin undertook first-hand studies of inheritance in families and built up the archives with their important records of human heredity. For many years his researches centered on the basic qualities in human races and, with financial assistance from W. J. Salmon, on the inheritance of racing capacity in the thoroughbred horse whose pedigree is known better than that of any human stock." Dr. Laughlin has taken up his residence in Kirksville, Missouri.

THE *Journal* of the American Medical Association reports that the Association of Military Surgeons of the United States has announced the annual competition for the Wellcome Gold Medal and cash prize of $500, awarded "for researches, discoveries, inventions, designs, improvements, essays or any other acts or deeds which the executive council of the association may consider desirable and helpful to the objects of the association, and relating to any phase of medico-military affairs and disease control associated with the army, navy, militia and public health and marine hospital service in times of peace or war at home or abroad." The competition is open to any member of or person eligible for membership in the Association of Military Surgeons of the United States. Additional information may be obtained from the secretary of the association, Army Medical Center, Washington, D. C.

AT the last annual meeting of the trustees of the Elizabeth Thompson Science Fund, the following grants were awarded: $200 to Dr. Robert Virtue, University of Denver, for a study of the effect of bile acids on fat absorption; $100 to Dr. Charles E. Renn, Harvard University, for a study of the decomposition in organic residues in natural marine and polluted fresh-water muds; $180 to Dr. J. F. McClendon, Uni-

versity of Minnesota Medical School, for thyroxine determinations in tissues; $157 to Dr. J. O. Pinkston, American University of Beirut Medical School, for studies on the pharmacological relationship between the sympathomimetic drugs and the chemical mediators of the sympathetic nervous system; $200 to Dr. Alfred C. Lane, Cambridge, Mass., for analyses of radioactive minerals; $150 to Dr. Alfred Romer, Harvard University, for aid in rewriting Williston's "Osteology of the Reptiles." The next meeting of the trustees will be held in April. Applications for grants should be made to the secretary, Dr. Jeffries Wyman, Jr., Biological Laboratories, Harvard University, Cambridge, Mass.

Nature states that the Ministry of Labor has announced that technical committees associated with University Recruiting Boards have been set up to deal with offers of service from men less than twenty-five years of age with qualifications in engineering, chemistry, metallurgy, physics, the biological sciences and mathematics, in order that they may be allocated to an appropriate form of national service. The committees will sit in all cities with universities or university colleges in Great Britain and Northern Ireland, and applications, which should be made in the first instance to a local office of the Ministry of Labor, will be referred to the technical committees and the University Recruiting Boards. This offer is open to men who are starting on their final year of a degree course, or already hold a university degree in any of the following subjects: engineering, chemistry, metallurgy, physics, the biological sciences (including agriculture) and mathematics (including statistics); and to men who are starting on their final year of study or already hold a Higher National Diploma or Higher National Certificate in mechanical or electrical engineering, or the associateship of the Institute of Chemistry.

IT is reported from Bucharest by the *Journal* of the American Medical Association that the government some time ago empowered the Ministry of Health to appoint technical committees to study public health problems and to make proposals regarding most urgent matters needing attention. In all, nineteen committees have been appointed to study typhus fever, malaria, eugenics, maternity and child welfare, insurance against tuberculosis, cancer, venereal diseases, rheumatism, malnutrition and deficiency diseases and dentistry with especial attention to the function of dental technicians. Committees are also being appointed to stimulate the campaign against alcoholism and trachoma, to promote the standardization of biologic products and to investigate means of fostering international relations in health matters.

IT is reported in *Nature* that the British Film Institute, London, one of the objects of which is to collect and disseminate information concerning the use of films for educational purposes, is engaged in compiling a bibliography on the scientific uses of cinematography. Very few books have been written on the subject, and the list will consist almost entirely of references to reports of scientific associations and to articles which have appeared in scientific and film journals. The institute would be glad to receive any information bearing on the undertaking.

DISCUSSION

ORIGINAL SOURCES IN VERTEBRATE EMBRYOLOGY AND ANIMAL CYTOLOGY

THE volume of current literature in the biological sciences has long been a matter of concern to investigators, teachers and librarians. For many years students have asked questions concerning the original sources of literature in vertebrate embryology and animal cytology, particularly in respect to the number of articles published and the journals containing these, which I, for one, could answer only in the most general way. The establishment of *Biological Abstracts* in 1927 was a most welcome event, and with the completion of its tenth volume, an opportunity to obtain statistical material presented itself. With the assistance of two undergraduate tabulators provided through NYA funds I have prepared the accompanying tables of the abstracts printed under the rubrics "Vertebrate Embryology" and "Cytology, Animal." These do not, of course, include all abstracts containing embryological data, for example, for those printed under other rubrics and referred to by cross-reference were not tabulated.

An examination of Table 1 shows that during the years 1927–1936 abstracts of 3,469 titles in vertebrate embryology appeared, an average of 347 titles annually. This output of embryological research may

TABLE 1

SOURCES AND NUMBERS OF ABSTRACTS CONCERNING VERTEBRATE EMBRYOLOGY FOUND IN "BIOLOGICAL ABSTRACTS," 1927–1936

Sources	594
Number of abstracts	3,469
Ten journals most frequently abstracted:	
Zeitschrift für wissenschaftliche Biologie (Berlin)	190
Anatomical Record (Baltimore)	144
Journal of Experimental Zoology (Baltimore)	138
Anatomische Anzeiger (Jena)	122
Journal of Anatomy (London)	111
Zeitschrift für die gesamte Anatomie (Munich)	101
Comptes rendus de séances, Société de Biologie (Paris)	99
Jahrbuch für Morphologie und mikroscopische Anatomie (Leipzig)	90
American Journal of Anatomy (Baltimore)	76
Archiv für experimentelle Zellforschung (Jena)	75
Subtotal	1,146
Per cent. of total	33

best be appreciated when it is remembered that Minot's well-known "Bibliography of Vertebrate Embryology," covering the literature up to 1892, contains only 3,555 references.

The abstracts summarized in Table 1 came from 594 sources, illustrating the difficulties of covering the literature encountered by the section editors concerned. We have listed in order the ten journals most frequently abstracted during this period, and it is of interest to note that these ten provided about one third of the total number of abstracts.

A similar table (2) contains the summaries of our tabulation of cytological literature, which is roughly about half as large; 251 sources were abstracted with a total of 1,518 abstracts, an average of 152 per annum. The ten journals listed were the source of approximately one third of the abstracts. It should be noted that the relative position of *Cytologia* and *Protoplasma* in the list of journals is due to the fact that they were founded during the period under consideration. For purpose of comparison the bibliography of E. B. Wilson's "The Cell in Development and Heredity" (1925 edition) was selected. This contains approximately 3,000 titles.

TABLE 2

SOURCES AND NUMBERS OF ABSTRACTS CONCERNING ANIMAL CYTOLOGY FOUND IN "BIOLOGICAL ABSTRACTS" 1927–1936

Sources	251
Number of abstracts	1,518
Ten journals most frequently abstracted:	
Journal of Morphology and Physiology (Baltimore)	84
Zeitschrift für wissenschaftliche Biologie (Berlin)	76
Comptes rendus de séances, Société de Biologie (Paris)	62
Anatomical Record (Baltimore)	55
Biological Bulletin (Woods Hole, Mass.)	53
Quarterly Journal of Microscopical Science (London)	45
Cytologia (Tokyo)	38
Protoplasma (Leipzig)	37
Archiv für experimentelle Zellforschung (Jena)	31
SCIENCE (New York)	31
Subtotal	512
Per cent. of total	34

The original list of sources from which abstracts of embryological articles had been prepared was checked against the Union List of Serials in Libraries of the United States and Canada. We were able to verify the correct title of 410 serials. A professional bibliographer might well have tracked down some additional titles, but many of our first list were of books and irregular publications not listed as serials. In Table 3 we present the distribution of these serials according to the language (or principal language) employed. While English appears to be the most widely used language in current embryological literature, the student who knows English only finds himself blocked from direct access to almost two thirds of the original sources. After German and French, in the order named, Italian seems to be the language most frequently employed.

TABLE 3

DISTRIBUTION BY LANGUAGES OF SERIALS CONTAINING ARTICLES ON VERTEBRATE EMBRYOLOGY ABSTRACTED IN "BIOLOGICAL ABSTRACTS" 1927–1936

Language of serial	Serials abstracted	Number of abstracts
English	131	1,217
German	85	958
French	70	422
Italian	42	244
Japanese[1]	26	108
Spanish	16	25
Russian[1]	10	25
All others	30	90
Total	410	3,089

[1] Usually with summaries in English, German or French.

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DIPLODIA STEM-END ROT OF LEMONS CONTROLLED WITH SODIUM ETHYL MERCURI THIOSALICYLATE

THAT the utilization of modern developments in the field of medical therapeutics may perhaps be worthy of more extensive trial in the field of plant pathology is indicated by recent experimental work on citrus fruit stem-end rot control. The efficiency of merthiolate (Lilly) or sodium ethyl mercuri thiosalicylate as a control for fungi affecting the animal body has suggested it for use against plant pathogens. In several successive tests during the fall of 1939, this antiseptic in the regular 1 to 1,000 tincture form, applied as a local stem-end treatment on lemons, has given practically perfect stem-end rot control after two-weeks incubation, during which controls rotted to the extent of 60 to 72 per cent. In one test, after three-weeks incubation, there was no loss in the treated fruits, while decay increased to 84 per cent. in the controls. Later tests showed that 1 to 5,000 dilutions were practically as efficient as the 1 to 1,000. Sulfo-merthiolate (Lilly) or sodium *p*-ethyl mercuri thiophenylsulfonate has likewise given almost complete control by the same method.

The stem-end treatments were applied by a "stamp pad" method, improvised during the tests, whereby a piece of heavy felt in a non-corrosive holder was kept moistened with the antiseptic solution. The individual fruits were presented with their stem ends against the felt, with a slight twisting motion (through about 60 degrees). This resulted in complete wetting of the "button" and the adjacent rind. The control recorded was undoubtedly due to both the high disinfectant properties of the chemicals and their excellent penetrating powers. Complete fruit-dip treatments for two minutes in 1 to 10,000 dilutions of both merthiolate and sulfomerthiolate gave 99 to 100 per cent. control in late season tests while controls were showing 27 and 35 per cent. decayed after a three-week incubation period.

While these promising chemicals appear to be rather expensive, records have shown that during

period of high incidence of stem-end decay in citrus fruits, costs of treatments by the "stamp pad" method are almost negligible in comparison with losses that are frequently encountered in shipments of non-treated or improperly treated fruit. Shipments of fruits showing excessive decay cause indirect damage to grower and shipper alike in that consumer ill-will is often difficult to overcome.

This preliminary report is made with the thought that it may stimulate practical research leading to better control of plant diseases from the use of these chemicals and others like them. At the concentrations used, the manufacturers state that there is no danger from toxic residues.

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THE EXPERIMENTAL PRODUCTION OF HEPATIC CIRRHOSIS BY THE SEED OF AMSINCKIA INTERMEDIA[1]

FEEDING trials have demonstrated the seed of *Amsinckia intermedia,* Fisch. and Mey., also variously known as fiddle-neck, yellow burweed, yellow tarweed and tarweed, to cause necrosis of the liver parenchyma of swine, horses and cattle. The hepatic cells are replaced by connective tissue producing an extremely hard, cirrhotic liver. Similar changes also occur in the spleen, although to a lesser degree. In swine, which are most susceptible, and in cattle, which appear to be more resistant, the condition is known as "hard liver disease." In horses, in which any extensive destruction of the hepatic parenchyma is followed by cerebral disturbances, the condition is known as "walking disease" because of the tendency of affected horses to wander aimlessly.

Amsinckia intermedia grows profusely in the grain fields in certain semi-arid regions in Washington, Oregon, Idaho and California. Because of its irritant character the plant is not grazed by live stock. The seeds are heavy and are harvested with the grain. They are non-irritant and possess a pleasant nut-like flavor and at first are readily eaten by live stock. After animals have been made acutely ill, they tend to avoid the seed.

All of nine pigs, all of three horses and one of three calves fed wheat screenings rich in the seed of *Amsinckia intermedia* developed hepatic cirrhosis with symptoms characteristic of those observed in animals on farms where the plant grows abundantly. An alcoholic extract, representing approximately one pound of the seed, killed a 30-pound pig in less than 12 hours. The liver parenchyma was badly damaged. Further feeding trials have shown the toxic principle to be contained in the petroleum ether insoluble fraction of such extracts.

While *Amsinckia intermedia* has been known to produce mechanical injuries,[2] and other members of the Borage family have been described as urticarious,[3] no member of this family previously has been shown to be toxic.

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AN EFFECT OF BENZEDRINE SULFATE ON CHICKS

MANY of the effects of the synthetic drug benzedrine sulfate (benzyl methyl carbinamine sulfate) are similar to those of epinephrine. It is used in inhalers to shrink the nasal mucosa, and has been used in the treatment of narcolepsy. When day-old Rhode Island Red chicks are given 1 mg of benzedrine sulfate subcutaneously they show visible effects of the drug in seven to nine minutes; mouths open, legs become unsteady so that the body falls forward, and the wings droop and spread. The most remarkable reaction is the incessant twitter or "singing," roughly 220 notes per minute, which continues for fifteen minutes to half an hour. All the visible effects disappear in about forty-five minutes.

When larger doses (3.5 mgs) are used the effects appear in two or three minutes and the rate of twittering is increased up to 300–330 notes per minute. Apparently the drug is eliminated rapidly as the chicks return to normal inside of an hour.

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ARE PECTIC SUBSTANCES PRECURSORS TO LIGNIN?

RED clover (*Trifolium pratense*), a lignified tissue, may contain pectic substances and lignin in practically equal amounts. In general, lignified tissues contain very small percentages of pectic substances and considerable lignin, while in non-lignified tissues the opposite is true. For these reasons, it has been thought that lignin is formed from pectic substances in the plant. In red clover, however, the proportion of these two substances does not indicate that one is the precursor of the other; however, it does support Bailey's[1] contention that, because of the difference in cell structure, it is not essential to account for the various proportions of these substances in different plants on the basis of transformations. Table 1 illustrates the percentages of pectic substances and lignin

[1] Published as Scientific Paper No. 427, Agricultural Experiment Station, State College of Washington.

[2] L. H. Pammel, *Vet. Med.*, 21: 220, 1926.

[3] Walter Conrad Muenscher, "Poisonous Plants of the United States," New York: Macmillan Company, 1939.

[1] I. W. Bailey, *Ind. Eng. Chem., Ind. Ed.*, 30: 40–47, 1938.

TABLE 1

	Pectic substances	Lignin
	Per cent.	Per cent.
Red clover (*Trifolium pratense*)	5.3 –7.8	6.8– 9.5
Kentucky blue grass (*Poa pratensis*)	0.7 –1.0	7.7–10.6
Timothy (*Phleum pratense*)*		10.4
Italian rye grass (*Lolium italicum*)†		10.4
Other grasses‡	0.82–2.10	
Leaves:		
Bean§	6.5 –8.9	.....
Cabbage§	7.4	.....
Hyacinth§	9.2	.....

* Max Phillips, *Jour. Assn. Official Agr. Chemists*, 16: 476–479, 1933.
† A. G. Norman, *Jour. Am. Soc. Agron.*, 31: 751–760, 1939.
‡ Harold William Buston, *Biochem. Jour.*, 28: 1028–1037, 1934.
§ *Ibid.*, 29: 196–218, 1935.

in red clover and various grasses as hay and in certain leaves. The results are expressed on a dry matter basis.

In view of recent developments, perhaps the pectic substances when present to this extent in a feed have a value other than a calorific one.

Seasonal trends of the content of pectic substances, hemicelluloses and lignin in red clover and Kentucky blue grass, together with a discussion of their relationships, will be published later.

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SPECIAL ARTICLES

THE PRODUCTION OF TUMORS BY INJECTION OF A CARCINOGEN INTO THE AMNIOTIC FLUID OF MICE[1]

VERY few, if any, attempts have been made to induce tumors by subjecting embryonic tissues to the action of carcinogenic agents. This report is to record the production of neoplasms in mice exposed to 1:2:5:6 dibenzanthracene as embryos *in uteri*.

The mice used were F_1 animals produced by crossings of Caracul ♀ × P stock ♂. The Caracul mice were inbred to the F_4 generation, while the P stock males were of the F_{13} generation. These F_1 embryos were heterozygous for the coat characters Caracul, a dominant waved mutation, albinism, pink-eye, extreme dilution and Agouti. It was hoped that with such animals possible somatic mutations could be observed. At the stage used in these experiments (14-day stage), the epidermis is composed of a single row of ectodermal cells and the Malpighian layer or *stratum germinativum*, which later gives rise to the hair follicles, has not yet differentiated.[2]

The vaginal plug method was used to detect fertilization. Fourteen days after plug formation the female was anesthetized with nembutal, the uterus exposed and approximately 0.5 minim of 1:2:5:6 dibenzanthracene in olive oil injected through the uterine wall directly into amniotic fluid of each embryo present. The dosage of carcinogen used was 4 mg of 1:2:5:6 dibenzanthracene per cubic centimeter of purified olive oil. Injections were made with a 27-gauge hypodermic needle. Abortion, resorption or birth of dead young were common. Premature birth occurred generally 17 days after plug formation so that the carcinogen was in contact with embryonic tissue for only 3 days in the majority of cases. Complete necropsies were done on all animals and histological sections made of all abnormal growths. (See Table 1.)

TABLE 1

FATE OF MICE OF EXPERIMENTAL SERIES A INJECTED WITH 1:2:5:6 DIBENZANTHRACENE AS EMBRYOS *in uteri*. ABSORPTION TIME REPRESENTS TIME FROM INJECTION OF CARCINOGEN INTO FLUID UNTIL PARTURITION. SEE TABLE 1 FOR TYPE REACTION IN THE LUNG.

Animal	Absorption time (days)	Age at time of necropsy (days)	Tumors
♀ F_1 122	6	197	No tumor
♂ F_1 121	4	169	Carcinoma lung +++
♀ F_1 120	3	223	Carcinoma lung ++
♂ F_1 119	3	196	Carcinoma lung +++
♀ F_1 118	3	196	Carcinoma lung +++
♀ F_1 117	3	196	Carcinoma lung ++
♂ F_1 116	5	186	Carcinoma lung +++
♂ F_1 115	5	186	Carcinoma lung +++
♂ F_1 114	5	186	Carcinoma lung ++
♀ F_1 113	5	186	Carcinoma lung +++
♂ F_1 112	3	196	Carcinoma lung +++
♂ F_1 111	3	196	Carcinoma lung +++
♀ F_1 110	3	224	Carcinoma lung ++
♀ F_1 109	3	224	Carcinoma lung ++
♀ F_1 108	3	196	No tumor
♀ F_1 107	3	196	No tumor
♀ F_1 106	3	183	Carcinoma lung +++; fibrosarcoma
♀ F_1 105	3	155	Carcinoma lung +++
♂ F_1 104	3	224	Carcinoma lung +++; carcinoma liver
♂ F_1 103	3	224	Carcinoma lung +++
♂ F_1 102	3	223	No tumor
♂ F_1 101	3	223	Carcinoma lung ++
♂ F_1 100	3	223	Carcinoma lung +++

There were but 23 animals of this experimental group which lived to maturity. Nineteen or 82.6 per cent., of these animals showed primary carcinoma of the lung when necropsied at an average age of 200.3 days. Five of these mice showed an extreme neoplasia involving most, or all, of the lung. Unfortunately, none of the experimental series was killed earlier than 155 days, at which time ♀ F_1 105 showed numerous large nodules in the lungs. Two animals showed multiple tumors. A tumorous growth above the skull appeared in ♀ F_1 106 at 163 days of age. Histological sections showed this to be a fibrosarcoma. At necropsy, 183 days, the lungs of this animal also showed extreme neoplasia. ♂ F_1 104 had extreme carcinoma of the

[1] The author is holder of a Finney-Howell Foundation Medical Research Fellowship.
[2] S. C. Reed and G. Sander, *Growth*, I: 194, 1937.

lung as well as carcinoma of the liver (see Table 1). It should be noted that in contrast to control animals all nodules in the lungs were easily visible with the naked eye.

In a second series (Series B), 0.5 minim of the same dosage dibenzanthracene in olive oil was injected intraperitoneally into F_1 mice 24 hours of age. Of this group necropsied at an average age of 180.8 days, 24 animals or 100 per cent. had carcinoma of the lung. Two animals also had fibrosarcomas in the region of the nape of the neck, although injections were made intraperitoneally.

There were two series of control animals. Twenty-nine mice received subcutaneous injections of the same dosage of dibenzanthracene when 2 months of age (Series C). Of this group, necropsied at an average age of 189.1 days, only 2 animals showed neoplasms, both carcinoma of the lung. In each case only a single nodule was detected under the dissecting microscope. Of 31 uninjected animals (Series D), necropsied at an average age of 228.4 days, only one animal had carcinoma of the lung, and this also was a single nodule detected by the dissecting microscope. All growths observed in the lungs were primary carcinomas. (See Table 2.)

TABLE 2

Series	Experiment	No. of mice	Average age at necropsy (days)	Number of tumors: Carcinoma lung	Number of tumors: Other tumors	Per cent. tumorous animals	Type reaction in lung
A	Injection of dibenzanthracene into amniotic fluid	11 ♀♀ 12 ♂♂	200.3	19	1 fibrosarcoma 1 carcinoma liver	82.6	6 ++ 8 +++ 5 ++++
B	Injection of dibenzanthracene into mice 24 hours of age (intraperitoneal)	11 ♀♀ 13 ♂♂	180.8	24	2 fibrosarcomas	100	4 ++ 6 +++ 14 ++++
C	Injection of dibenzanthracene into mice 2 months of age (subcutaneous)	16 ♀♀ 13 ♂♂	189.1	2	0	6.9	2 +
D	Uninjected controls	16 ♀♀ 15 ♂♂	228.4	1	0	3.2	1 +

+ = Single nodule. Detected in each case by use of dissecting microscope; ++ = few nodules, 5–10 visible with naked eye; +++ = numerous nodules, 10–20; ++++ = many nodules, 20 +, or tumor involving all, or most of, lung tissue.

It is of interest to note that the total maximum amount of dibenzanthracene present in the amniotic fluid, providing all remained subsequent to the injection, was but 0.125 mg per embryo. Since the average absorption time was only 3.5 days, it is quite probable that the minimum dosage required for tumor formation in the lungs of the F_1 mice under these conditions is considerably less than 0.125 mg. Previous reports[3,4] have indicated that as little as 0.1 mg of dibenzanthracene, in cholesterol-pellet form, would induce tumors at the site of injection in a very small percentage of animals.

No somatic mutations were observed among the 23 mice injected *in uteri* at the 14-day stage.

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ANAPHASE MOVEMENT IN ALLIUM CERNUUM

AT the first microspore division of many seed plants the orientation of the spindle at right angles to a wall makes it possible to determine the rate of anaphase movement for each group of daughter chromosomes. One spindle pole, at which the generative nucleus is later differentiated, appears to be pressed against a wall of the microspore; the other, at which the vegetative or tube nucleus is to be formed, extends into the cytoplasm. Thus at anaphase the generative group of chromosomes moves toward the wall, while the vegetative group moves away from the wall.

To determine the relative rate of movement of each group of chromosomes, measurements were made from permanent smears of *Allium cernnum* fixed in La Cour's 2BE and stained in crystal violet. Measurements were made from camera lucida drawings at a magnification of 3660×. Metaphases were measured from side view with respect to the distance from the wallward edge of the generative chromosomes at the centromere to the inner edge of the microspore wall. The thickness of the metaphase chromosome at the centromere was also determined. The sum of these two measurements is the distance from the centromeres of the vegetative chromosomes to the wall. Anaphases were measured from side view with respect to the distance between the two groups of centromeres and the distance from the generative centromeres to the wall. The distance from the centromeres of the vegetative chromosomes to the wall is the sum of these two mea-

[3] M. J. Shear and Egon Lorenz, *Am. Jour. Cancer*, 36: 201, 1939.

[4] F. W. Ilfeld, *Am. Jour. Cancer*, 26: 743, 1936.

surements. The anaphases measured were divided into four classes according to the distance between the centromeres. Class I includes anaphases in which the centromeres of the daughter groups of chromosomes are 2 μ to 5 μ apart; Class II 5 μ to 8 μ apart; Class III 8 μ to 10 μ apart; Class IV over 10 μ apart. The average distance between the centromeres and the average distance from the generative centromeres to the wall was obtained for each class.

The distance traveled by each daughter group of chromosomes is the difference between its position at metaphase and its position at anaphase. At metaphase the generative centromeres are 3.9 μ from the wall; the vegetative centromeres are 5.0 μ from the wall (average of 50 measurements). In Class I the daughter groups of centromeres are 3.8 μ apart; the generative centromeres are 3.4 μ from the wall (average of 13 measurements). Thus when the daughter groups of chromosomes are 3.8 μ apart the generative chromosomes have traveled 3.9 μ less 3.4 μ or .5 μ. The distance traveled by the vegetative chromosomes is 7.2 μ less 5.0 μ or 2.2 μ. The ratio of distance traveled by the vegetative chromosomes to the distance traveled by the generative chromosomes is 4.4:1. The average distance traveled by each group of chromosomes at different anaphase stages and the ratio of vegetative chromosome to generative chromosome movement is shown for *Allium cernnum* in Table 1.

TABLE 1

	Metaphase	Anaphase Class I	II	III	IV
Average distance (μ): between centromeres ..	1.1	3.8	6.4	9.0	10.7
from gen. centromeres to wall	3.9	3.4	2.3	1.0	0.6
travelled by gen. chromosomes	..	0.5	1.6	2.9	3.3
travelled by veg. chromosomes	..	2.2	3.7	5.0	6.3
Number of measurements	50	13	33	40	53
Veg./Gen. ratio	..	4.4	2.3	1.8	1.9

It must be pointed out that the daughter groups do not merely travel different distances but travel at different rates; *i.e.*, it is not a case of the generative group being stopped by the wall while the vegetative group continues its movement. If this were so we would expect to find the distance traveled by each of the two groups to be the same until the generative group reaches the wall, then the daughter groups would be about 8.9 μ apart (twice the distance from the generative centromeres to the wall plus the thickness of the metaphase chromosome). As shown in the table, this is not the case. When the daughter groups are 6.4 μ apart the vegetative group has traveled 3.7 μ; the generative group only 1.6 μ, and it is still 2.3 μ from the wall.

Whether difference in rate of movement of the two groups of chromosomes results primarily from a stretching of the anaphase spindle, as suggested by Geitler (1935),[1] or from a difference in time of development of the two spindle poles will be discussed in a later report which is concerned with anaphase movement in *Allium cepa, Pancratium illyricum, Tradescantia* and *Vicia faba,* as well as *Allium cernuum.*

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MULTIPLE GROWTH LAYERS IN THE ANNUAL INCREMENTS OF CERTAIN TREES AT LUBBOCK, TEXAS[1]

A NOTABLE feature of the climate of Lubbock, on the High Plains of Texas, is the common occurrence of heavy frost after tree growth has begun for the season. These frosts are sufficiently intense to rupture the newly formed cells in the branches and leaders of many trees and to cause the formation of a partial or entire "frost ring" in the wood. Since the injuries must take place early in the spring, which is soon after growth begins, their presence marks the actual beginning of growth for the particular years. Definite frost injuries occurred in 1932, 1933, 1934, 1936 and 1938, slight and restricted injury in 1937, and no injury in 1935. These dates, established by examination of the wood, were verified by meteorological and vegetational records.

Once determined and dated, the frost injuries furnish a unique method of recognizing the true extent of wood formed during one year, because, with the injuries occurring as listed above, they register the beginning of each year's growth. This is commonly true for all years except 1935, in which temperatures did not sink sufficiently low to cause injury. Thus the method permits the determination of whether or not the trees studied form one or more "rings" per year.

All the trees reported upon here, except one, grew on the campus of Texas Technological College. Most of the work was done on the Arizona cypress and western yellow pine, but four other species were also examined. Many thin sections were made from different branches of the same tree, from different points along one branch axis, and, in two cases, from leaders.

Two anatomical observations are worthy of record at the present stage of the work: the number of growth layers in an annual increment, and the forms of the layers. In this connection the term "annual increment" refers to the total amount of wood formed during a complete growing season, and "growth layer" refers to a "ring" composed of early and late wood whose outer margin is sharply set off from the succeeding layer. An annual increment contains one or

[1] L. Geitler, *Planta.*, 24: 361–386, 1935.

[1] A paper read at the Alpine, Texas, meetings of the Southwestern Division of the American Association for the Advancement of Science, May, 1939.

more growth layers, depending upon how many times the tree ceased and then resumed growth during a season.

It was found that the annual increments in the various specimens of Arizona cypress contained from one to five growth layers. In a certain branch of a western yellow pine the years 1936–1937 contained five growth layers. No clue existed whereby the end of 1936 and the start of 1937 could be identified. The difficulty was overcome in a second branch, where frost injury indicated the beginning of 1937 growth. Thus, 1936 contained two and 1937 three growth layers. It must be added that the growth layers of one branch corresponded in relative thicknesses with those of the other.

In brief, the forms of the layers may be classified roughly as lens and non-lens. A layer forms a lens if its late wood merges with that of the layer next inside, that is if it fails to form a completely independent ring. Both types were observed to have sharp outer margins in some cases, diffuse in others, or partially sharp and partially diffuse. In addition, the lens type as a rule did not constitute an entire annual increment. It is obvious that sharp layers could be mistaken for annual increments in trees devoid of frost injuries.

The following conclusions may be tabulated: (1) When present, frost injuries in the trees on the campus of Texas Technological College give a unique method of determining with exactness the amount of xylem formed each year. (2) Within the annual increments for 1932 to 1938 multiple growth layers are by no means uncommon—layers indistinguishable from a single annual increment under any magnification up to 400×. (3) A single radius, or even an entire section, may not be a safe guide to the correct age of a tree. (4) Under any ecologic conditions, complex as they are known to be, it would seem to be scientifically unsound to reason theoretically concerning the unity or multiplicity of growth layers in the annual increments. Thorough investigation and experiment by means of well-known botanical techniques are necessary for each general environment in order to determine the behavior of the cambium and the resultant anatomy of the annual increment. In the work here briefly reported, frost injuries fortunately gave the necessary accuracy to dating and thus have been used as a substitute for other more thorough types of investigation. (5) No ecologic interpretations are attempted. Suffice it to say that those conditions which cause the cessation of cambial division *at the end* of the growing season can operate equally well to cause cessation with like results *within* the growing season not only once but several times.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLE GRAVIMETRIC ALCOHOL CHECK FOR CALIBRATION OF METABOLISM APPARATUS

FOR alcohol checks of metabolism apparatus we have recently made two improvements on the standard procedures.[1] One improvement is the use of a small detachable lamp for weighing, which eliminates the use of a calibrated burette. The other is the elimination of the complicated water-cooled burner described by Barrett and Robertson.[2]

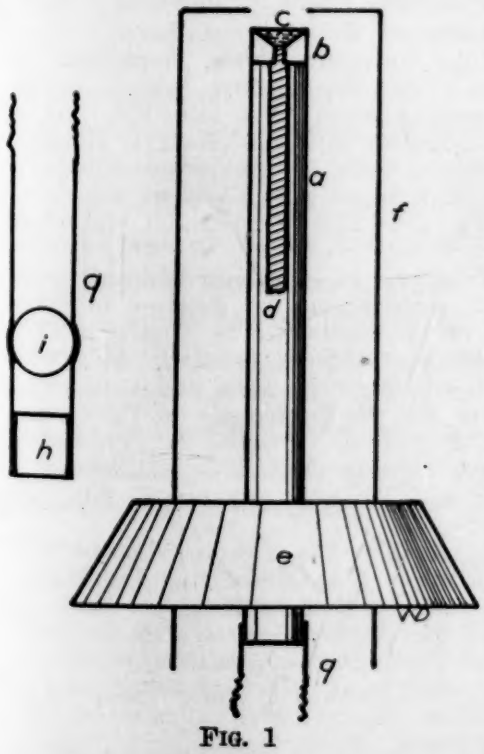

FIG. 1

As shown, the lamp consists of a pyrex glass tube (3/16″ by 5″), *a,* to which is fused a pyrex capillary tip, *b.* Asbestos fibers, *c,* prevent combustion of the wick, *d,* a piece of cotton binding cord. The large tube, *a,* by affording air insulation, eliminates boiling of the alcohol and the consequent loss due to sputtering. For weighing, a fine suspension wire (not shown) is attached to the No. 13 rubber stopper, *e.* Copper wires, *f,* for ignition connect to a spark coil. In Benedict-Roth machines the artificial circulation of air is perhaps most simply achieved by the method of Benedict.[1]

OPERATION

The thin-walled rubber tubing (3/16 inches by 6

[1] F. G. Benedict, *Boston Med. and Surg. Jour.,* 193: 807, 1925.

[2] J. F. Barrett and J. D. Robertson, *Jour. Path. and Bact.,* 45: 555, 1937.

inches), *g*, is detached, and the glass bead and plug, *h*, removed to facilitate filling. The weighed unit is inserted into a long cylindrical glass hood whose side arms connect to the metabolism system. By means of the bead, *i*, the level of the absolute methyl alcohol is maintained at the lower end of the wick, thus insuring a small, non-luminous flame. Near the end of the check, after the spark coil switch has been closed again to avoid escape of unburnt vapors, the supply is discontinued. When the flame dies out, to prevent evaporation, the alcohol in the tube is allowed to drop back into the reservoir created below the bead. Weighings are performed without delay. Used in testing a closed circuit respiratory metabolism apparatus, this method gave on seven checks values of 100 ± 0.5 per cent. for oxygen, carbon dioxide and water.

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DEFOLIATION OF ROSE PLANTS WITH ETHYLENE GAS[1]

INVESTIGATIONS by the Oregon Experiment Station have shown that ethylene gas can be used to remove the foliage from field-grown rose plants. The treatment is used after the roses have been dug for shipment or storage. One Oregon nurseryman has defoliated over 200,000 rose plants by this method this year; 50,000 of these were defoliated in a single room in four days' time. By other methods commonly used by the growers it would have taken several weeks to defoliate this same number of plants.

The fact that ethylene will defoliate rose plants is not new. Wilcox[2] in 1911 reported that illuminating gas would defoliate greenhouse roses. Since that time other workers have noted a similar effect on rose plants grown in greenhouses. In 1931 Zimmerman, Hitchcock and Crocker[3] demonstrated that ethylene present in illuminating gas or pure ethylene would cause epinasty and defoliation of potted rose plants. Roses thus treated would recover and show no effects of the treatment other than the forcing of more of the latent buds.

The above findings have been reinvestigated and procedures developed whereby this same principle can be used on a commercial scale to defoliate large numbers of nursery-grown rose plants. A fairly airtight room or chamber is provided, and ripe apples are used as the chief source of ethylene gas, although the hypanthia of the rose plants are known to produce some ethylene. One bushel of apples is sufficient for each 300 to 400 cubic feet of space. A temperature of 65° to 70° Fahrenheit is maintained during the treatment by electric or kerosene heaters. Where 50 per cent. or more of the space is filled with rose bushes the heat liberated by the rose plants, once the defoliation process has been started, is sufficient to maintain this temperature in insulated rooms. The plants can be stacked close together in large piles of single rows, but they must be kept in a moist condition to prevent wilting of the foliage. Defoliation with most varieties requires three to five days, but a few varieties require a longer treatment.

Numerous tests have been conducted to determine the behavior of rose plants following the treatment with ethylene. Treated and untreated lots of plants have been grown under field and greenhouse conditions. The treatment apparently has no significant effect upon the subsequent growth of the plants.

Preliminary trials with other plants suggests the possible application of the method to a number of nursery stocks other than roses.

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[1] Published as Technical Paper No. 328 with approval of Director, Oregon Agricultural Experiment Station, contribution from Departments of Horticulture and Plant Pathology.

[2] E. Mead Wilcox, Nebraska State Hort. Soc. Ann. Rept., pp. 278–285, 1911.

[3] P. W. Zimmerman, Wm. Crocker and A. E. Hitchcock, Contr. from Boyce Thompson Institute, 3: 459–481, 1931.

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